The state, C to D, is highly sustained with nearly constant amplitude. Oscillations lasted for nearly 2 hr (only a part of which is shown in Fig. 1). One may have some doubt that sulphate ion obtained from manganous sulphate or potassium sulphate in the agar agar bridge may have caused oscillations. But this is negated by the fact that Rastogi and coworkers[5,6] could not obtain oscillations in cerium and manganese catalysed Belousov-Zhabotinskii reaction when sulphuric acid concentration was less than $0 \cdot 4N$.

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Graph Theoretical Interpretation of Existence of Large Catacondensed Rings

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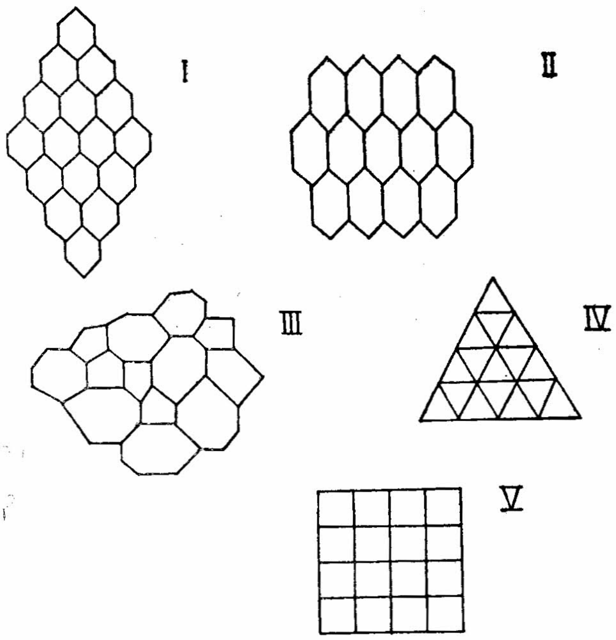
From graph theoretical considerations it has been shown that only three-, four- and six-membered rings can give extended catacondensed planar structures. Catacondensed structures from five- or seven-membered rings, if they exist, should be non-planar.

It is well known that benzene rings can fuse together to form catacondensed hydrocarbons (I) which can be synthesized by various chemical means[1]. When this fusion extends to infinity we get graphite which have unique electrical and magnetic properties. Catacondensed systems containing fused five (II) and seven (III) membered rings have also been prepared, but in these cases fusion has not proceeded very far, and large systems obtainable from six-membered ring systems have not been prepared[2]. It has often been asked if graphite-like structure could be prepared with five- and seven-membered ring systems and if they will have unique electrical and magnetic properties as distinct from normal graphite.

We may analyse the possibility of such systems mathematically from the graph theoretical con-



siderations[3]. Let us consider a system of the type (I). Let us assume there are n_v vertices (occupied by atoms), n_e edges (represented by bonds) and n_f faces bounded by edges. Let ϱ be the number of edges at each vertices which is evidently different from the ϱ^* which gives the boundary edges. If n_b be the number of vertices at the boundary, we have

$$\frac{n_b}{n_v} \to 0 \text{ as } n_v \to \infty \qquad \ldots(1)$$

If the number of edges at each vertices is ϱn_v and the boundary edges is ρn_b then

$$\rho n_v - \rho n_b < 2n_e < \varrho n_v \qquad \ldots(2)$$

where n_e is the total number of edges in the graph. This may be written as

$$\frac{\varrho}{2} - \frac{\varrho}{2}\frac{n_b}{n_v} < \frac{n_e}{n_v} < \frac{\varrho}{2} \qquad \ldots(3)$$

We, thus, conclude that

$$\frac{n_e}{n_v} \to \frac{\varrho}{2} \text{ as } n_v \to \infty \qquad \ldots(4)$$

Now each edge lies on the boundary of just two faces. So there are $n_f - 1$ faces with ϱ^* boundary edges and the face f_∞ has n_b boundary edges, same as the number of boundary vertices. This leads us to conclude that

$$2n_e = (n_f - 1)\varrho^* + n_b$$

or

$$\frac{n_f}{n_v} = \frac{2}{\varrho^*}\frac{n_e}{n_v} + \frac{1}{n_v} - \frac{1}{\varrho^*}\frac{n_b}{n_v} \qquad \ldots(5)$$

As $n_v \to \infty$ we get

$$\frac{n_f}{n_v} \to \frac{\varrho}{\varrho^*} \qquad \ldots(6)$$

The Eulers equation[3] for planar graph states

$$1 + \frac{n_f}{n_v} = \frac{n_e}{n_v} + \frac{2}{n_v} \qquad \ldots(7)$$

For $n_v - \infty$ we have

$$1 + \frac{\rho}{\rho^*} = \frac{\rho}{2} \qquad \ldots(8)$$

or

$$(\rho - 2)(\rho^* - 2) = 4$$

This is a perfectly general relation for a planar graph, and is independent of the number of vertices or edges on a face. The only pairs of integers which satisfy this relation are: $\rho = 3$, $\rho^* = 6$, $\rho = 4$, $\rho^* = 4$ $\rho = 6$, $\rho^* = 3$. The structures which satisfy this relation are I, IV and V.

This implies that large planar structures may be built only from triangle, square and hexagon. This analysis, however, does not preclude non-planar system containing five- or seven-membered rings.

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